IS 6104 (1971): Method of test for interfacial tension of oil against water by the ring method [ETD 3: Fluids for Electrotechnical Applications]

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IS : 6104 - 1971
(Reaffirmed 1977)

# Indian Standard

## METHOD OF TEST FOR INTERFACIAL TENSION OF OIL AGAINST WATER BY THE RING METHOD

(Second Reprint DECEMBER 1983)

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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*June* 1972

AMENDMENT NO. 1 APRIL 1985

TO

IS:6104-1971 METHOD OF TEST FOR INTERFACIAL TENSION OF OIL AGAINST WATER BY THE RING METHOD

(*Page 8, clause 8.2, equation*) - Substitute the following for the existing equation:

$$'F = 0.725 + \sqrt{\frac{0.014\ 52 \times 10^5 \times P}{C^2\ (D-d)} + 0.045\ 34 - \frac{1.679}{R/r}}$$

where

$P$ = scale reading, N/m;

$C$ = circumference of ring, mm;

$D$ = density of water at 25°C, kg/lit;

$d$ = density of sample at 25°C, kg/lit;

$R$ = radius of ring, mm; and

$r$ = radius of wire of ring, mm.'

(ETDC 64)

Reprography Unit, ISI, New Delhi, India

# *Indian Standard*
# METHOD OF TEST FOR INTERFACIAL TENSION OF OIL AGAINST WATER BY THE RING METHOD

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# *Indian Standard*

# METHOD OF TEST FOR INTERFACIAL TENSION OF OIL AGAINST WATER BY THE RING METHOD

## 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 28 December 1971, after the draft finalized by the Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

**0.2** The interfacial tension of oil used for transformers and switchgear is an important criteria which gives an indication of its capability for use as an insulating medium. This standard has, therefore, been prepared to evaluate this requirement.

**0.3** In preparing this standard, assistance has been derived from ASTM Designation D 971-50 'Standard method of test for interfacial tension of oil against water by the ring method ' issued by the American Society for Testing and Materials.

**0.4** In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance the IS: 2-1960*.

## 1. SCOPE

**1.1** This standard describes a procedure for measuring, under non-equilibrium conditions, the interfacial tension of mineral oils against water, which has been shown by practice to give a reliable indication of the presence of hydrophilic compounds.

## 2. OUTLINE OF METHOD

**2.1** Interfacial tension is determined by measuring the force necessary to detach a planar ring of platinum wire from the surface of the liquid of higher surface tension, that is, upward from the water-oil interface. To calculate the interfacial tension, the force so measured is corrected by an empirically determined factor which depends upon the force applied, the

*Rules for rounding off numerical values (*revised*).

densities of both oil and water, and the dimensions of the ring. Measurements are made under rigidly standardized non-equilibrium conditions in which the measurement is completed within one minute after formation of the interface.

## 3. APPARATUS

**3.1** The following apparatus is required (*see* Fig.1) :

a) *Tensiometer** — with a torsion wire to apply the force to lift the ring; the torsion wire is attached to a scale graduated in N/m.

b) *Ring* — of fine platinum wire in a nearly true circle of 40 or 60 mm circumference welded to a suitable stirrup made of the same wire. It is necessary to know, to three significant figures, the circumference of each ring, and the ratio of the diameter of the ring to the diameter of the wire of which it is made.

c) *Sample Container* — Glass beaker or cylindrical vessel having a minimum diameter of 45 mm.

## 4. PREPARATION OF APPARATUS

**4.1** Clean all glassware by removing any residual oil with petroleum naphtha or benzene followed by several washes with methyl ethyl ketone and water and immersion in a hot cleaning solution of chromic acid. Rinse thoroughly with tap water and then with distilled water. Unless it is to be used immediately, drain the sample container in an inverted position over a clean cloth.

**4.2** Clean the platinum ring by rinsing it in petroleum nephtha or benzene followed by rinsing in methyl ethyl ketone. Then heat the ring in the oxidizing portion of a gas flame.

## 5. CALIBRATION OF APPARATUS

**5.1** Calibrate the tensiometer against known weights and adjust its zero point according to the procedure of its manufacturer. Make certain that all portions of the ring are in the same horizontal plane.

## 6. SAMPLE

**6.1** Filter the sample through a 150 mm diameter, unwashed filter paper of medium porosity (for example, Whatman No. 1), using fresh paper for each 25 ml portion of oil. Determine the density of the filtered oil to the nearest 0.001 g per ml 27°C.

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*Tensiometers which use the Du Nouy principle for measuring interfacial and surface tension should be used.

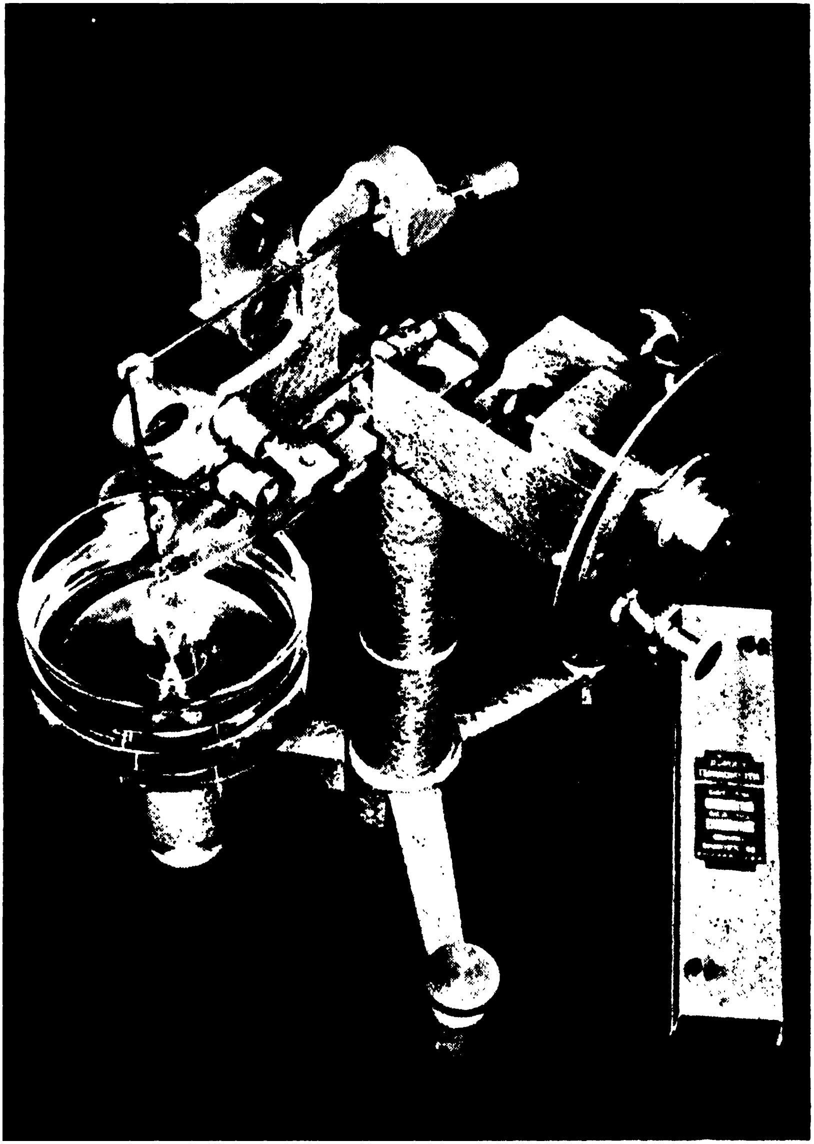

Fig. 1 INTERFACIAL TENSIOMETER

## 7. PROCEDURE

**7.1** Introduce 50 to 75 ml of distilled water at a temperature of 27 ± 1°C to a freshly cleaned sample container and place it on the adjustable platform of the tensiometer. Clean the platinum ring (*see* **4.2**) and suspend from the tensiometer. Raise the adjusting platform until the ring is immersed in the water to a depth not exceeding 6 mm in the centre of the sample container as determined by visual observation.

**7.2** Slowly lower the platform, increasing the torque of the ring system by maintaining the torsion arm in the zero position. As the film of water adhering to the ring approaches the breaking point, proceed slowly with adjustment to assure that the moving system will be in the zero position when rupture occurs. Using the scale reading at which this occurs, calculate the tension of the water sample as described in **8** using the value 0.997 for the difference of density of water and air ($D—d$); a value of 0.071 to 0.072 N/m should be obtained. When low values are found, possibly due to improper adjustment of the tensiometer or improperly clean apparatus, make re-adjustment; clean the sample container with hot chromic acid cleaning solution, rinse, and repeat the measurement. If a low value is still obtained, further purify the distilled water (for instance, by re-distilling from an alkaline solution of potassium permanganate).

**7.3** Return the tensiometer scale to zero and raise the adjustable platform until the ring is immersed to a depth of about 5 mm in the distilled water. Pour the filtered oil, previously brought to a temperature of 27 ± 1°C on the water to a depth of about 10 mm. Take care that the ring does not touch the oil-water interface. If a ring with a short stirrup is used keep the oil level below the top of the stirrup to prevent bridging. If this is not possible, break the bridge with a suitable clean, sharp instrument as soon as possible after withdrawing the stirrup from the oil.

**7.4** Allow the oil-water interface to age for 30 ± 1 sec, then slowly lower the platform, increasing the torque of the ring system by maintaining the torsion arm in the zero position. As the water adhering to the ring approaches the breaking point, proceed slowly with adjustment to assure that the moving parts will be in zero position when rupture occurs. Time these operations so that, as nearly as possible, 30 sec are required to draw the ring through the interface. Proceed very slowly as the breaking point is approached, since the break is usually sluggish and too rapid movement may result in a high reading. Complete the entire operation, from the time of pouring the oil into the sample container until the film ruptures, in about one minute. Record the scale reading at which the ring breaks free from the interface.

## 8. CALCULATION

**8.1** Calculate the interfacial tension of the sample by means of the following equation:

Interfacial tension, N/m = $P \times F$

where

$P$ = scale reading in N/m when film ruptures *(see* Note), and
$F$ = factor for converting scale reading in N/m to interfacial tension, obtained as described in **8.2.**

NOTE — If the scale is not graduated in N/m, or if either the ring or the platinum wire are of different diameters than those for which the scale is graduated, correct the scale readings to N/m for the particular ring used.

**8.2** Using the value of diameter ratio, *R/r*, specified by the manufacturer for the rings used, prepare a graph of correction factors, *F*, by means of the following equation; the graph should cover even increments of *P/(D—d)* from 0 to 800 and should give correction factors to three digits:

$$F = 725{\cdot}0 + 10^{3}\sqrt{\frac{0{\cdot}014\,52 \times 10^{6}P}{C^{2}\,(D-d)} + 0{\cdot}045\,34 - \frac{1{\cdot}679}{R/r}}$$

where

$P$ = scale reading, N/m;
$C$ = circumference of ring, mm;
$D$ = density of water at 27°C, kg/1;
$d$ = density of sample at 27°C, kg/1;
$R$ = radius of ring, mm; and
$r$ = radius of wire of ring, mm.

## 9. PRECISION

**9.1** Results should not differ from the mean by more than the following amounts:

| *Repeatability* | *Reproducibility* |
|---|---|
| Same operator and apparatus | Different operators and apparatus |
| 2 percent of mean | 5 percent of mean |

# INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

## Base Units

| *Quantity* | *Unit* | *Symbol* |
|---|---|---|
| Length | metre | m |
| Mass | killogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Thermodynamic temperature | kelvin | K |
| Luminous Intesity | candela | cd |
| Amount of substance | mole | mol |

## Supplementary Units

| *Quantity* | *Unit* | *Symbol* |
|---|---|---|
| Plane angle | radian | rad |
| Solid angle | steradian | sr |

## Derived Units

| *Quantity* | *Unit* | *Symbol* | *Conversion* |
|---|---|---|---|
| force | newton | N | 1 N = 1 kg. 1 $m/s^2$ |
| Energy | joule | J | 1 J = 1 N.m |
| Power | watt | W | 1 W=1 J/s |
| Flux | weber | Wb | 1 Wb = 1 V.s |
| Flux density | tesla | T | 1 T =1 $Wb/m^2$ |
| Frequency | hertz | Hz | 1 Hz=1c/s($s^{-1}$) |
| Electric conductance | siemens | S | 1 S=1A/V |
| Pressure, stress | pascal | Pa | 1 Pa = 1 $N/m^2$ |


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